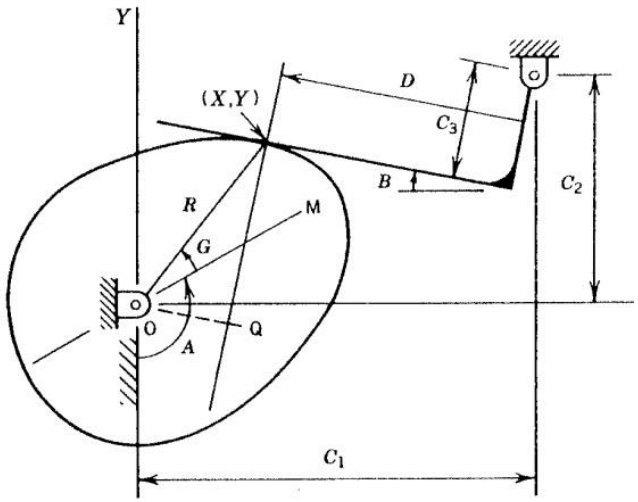
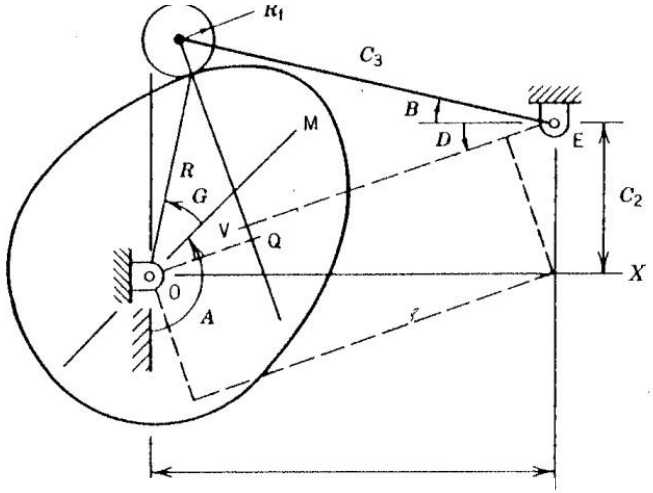




Mecanismos

Prof. Jorge Luiz Erthal

jorgeerthal@gmail.com

Síntese de cames

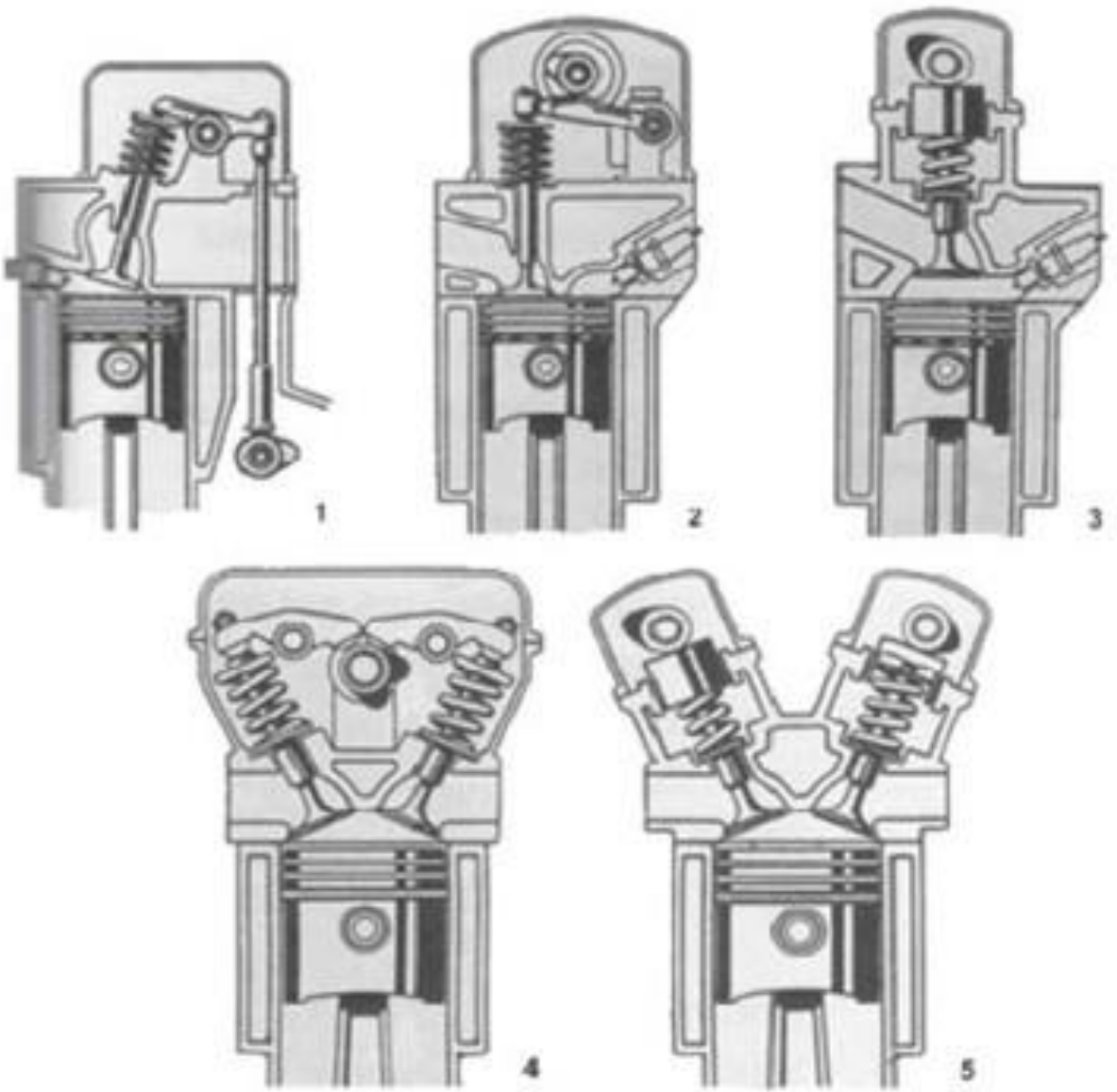
com seguidor oscilante

Atualizado em 02/05/2019

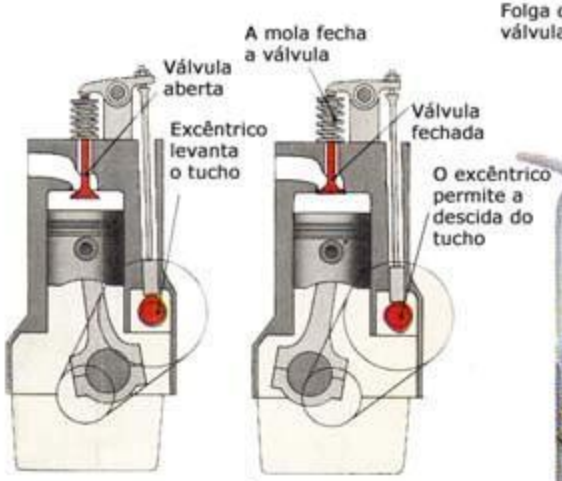
Nesta aula

- Síntese de cames com seguidor oscilante de face plana
  - Largura da face do seguidor
  - Coordenadas do perfil da came
  - Raio de curvatura
- Síntese de cames com seguidor oscilante com rolete
  - Coordenadas do perfil da came
  - Orientação da linha de contato
  - Raio de curvatura

DIFERENTES TIPOS DE ACCIONAMIENTO DE VALVULAS

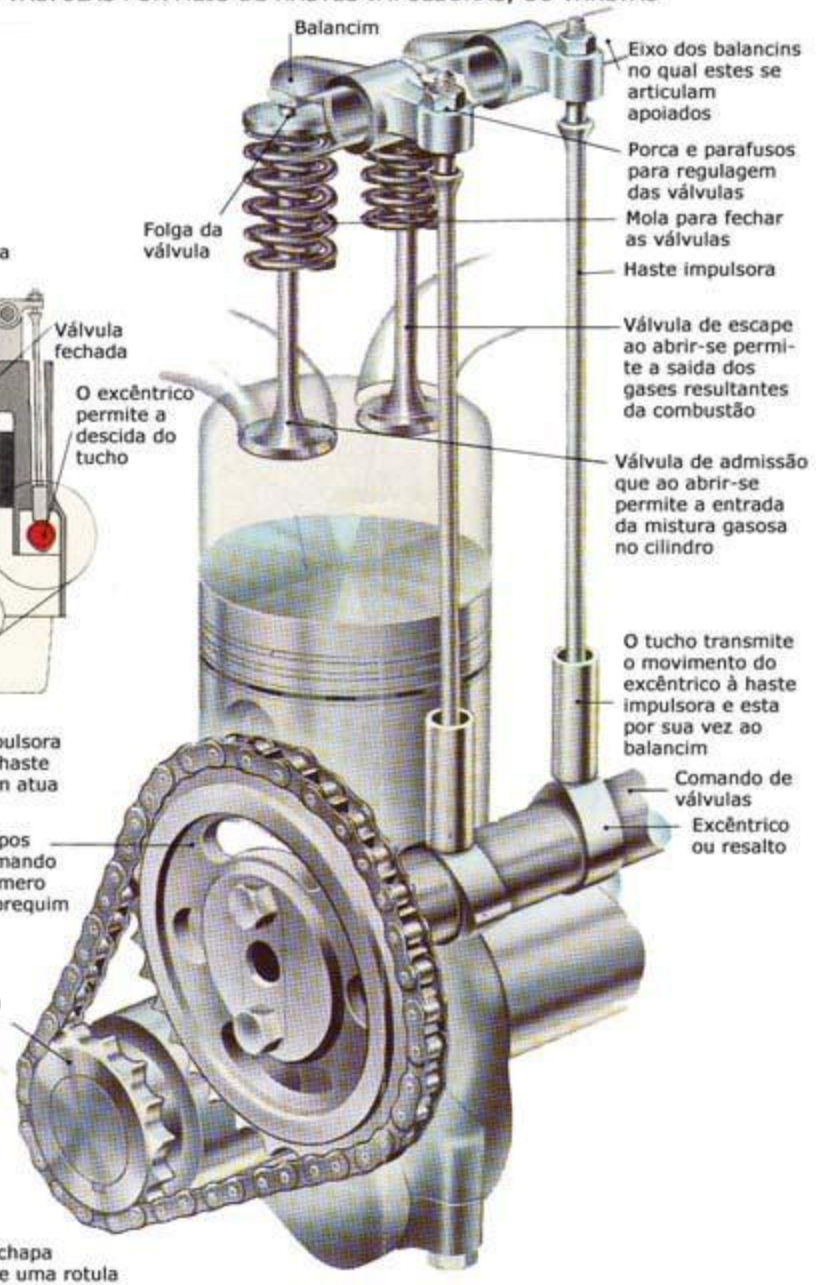


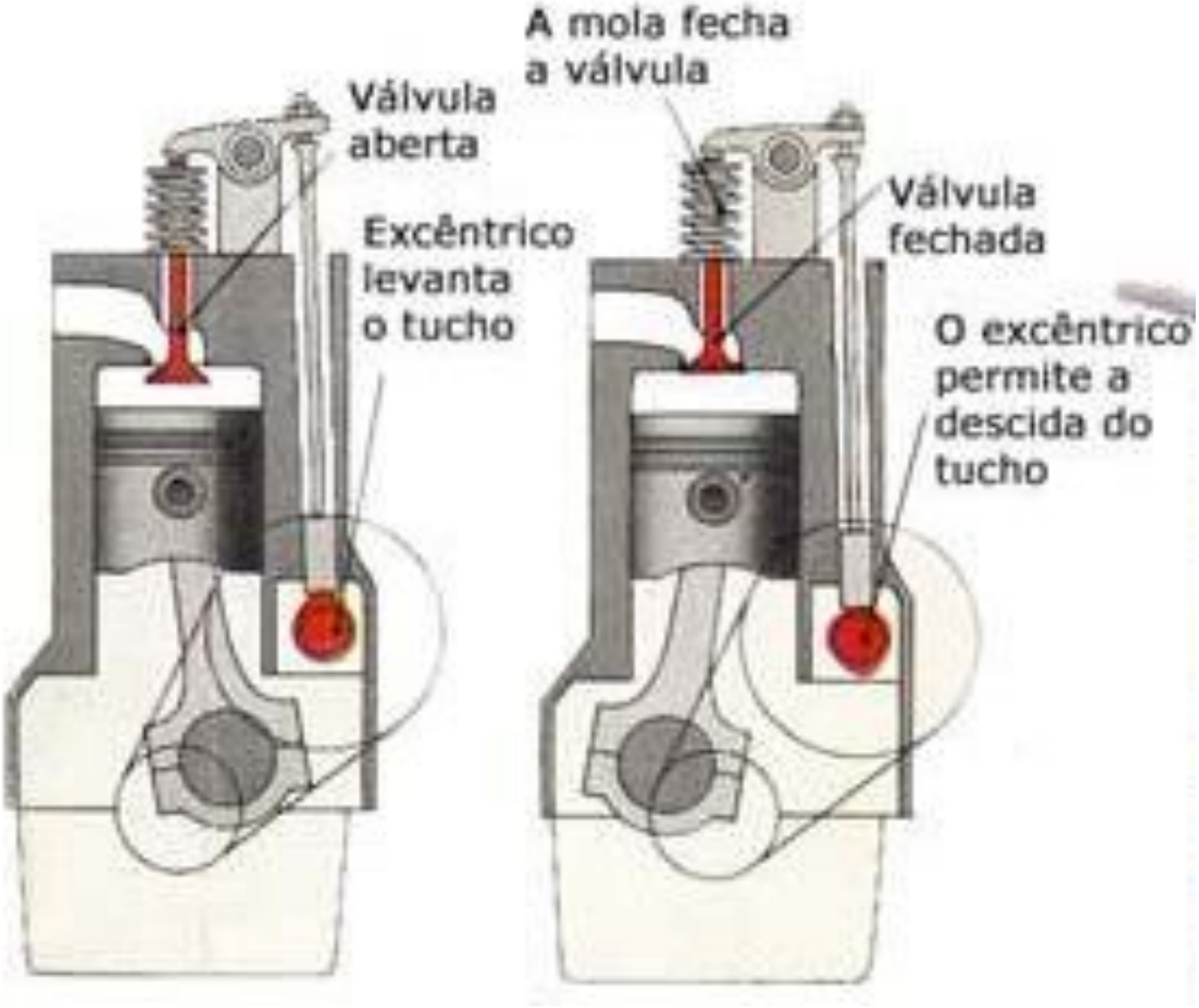
ACIONAMENTO DAS VÁLVULAS POR MEIO DE HASTES IMPULSORAS, OU VARETAS



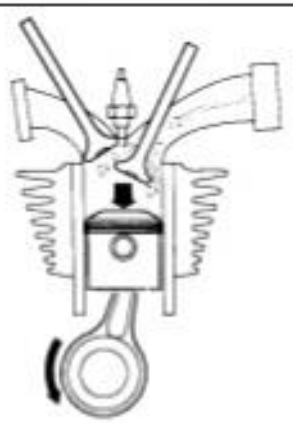
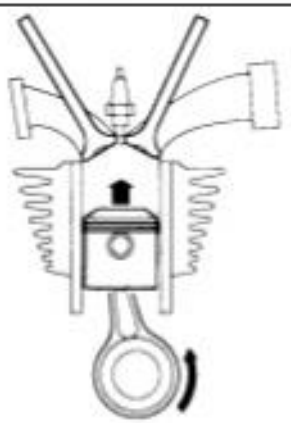
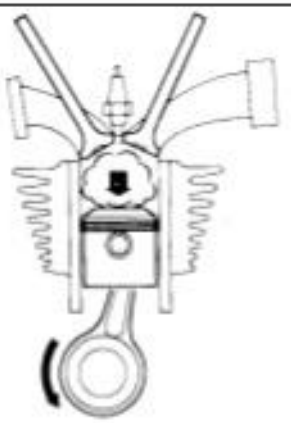
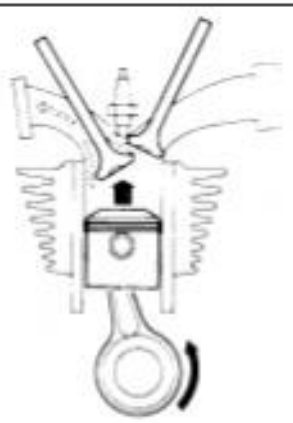
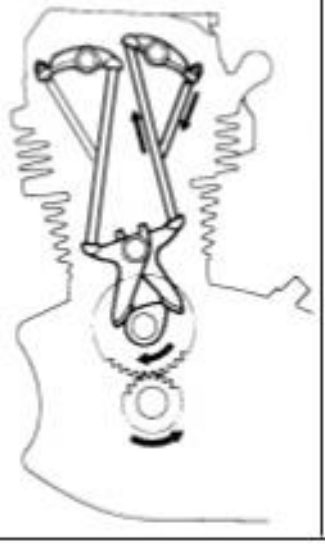
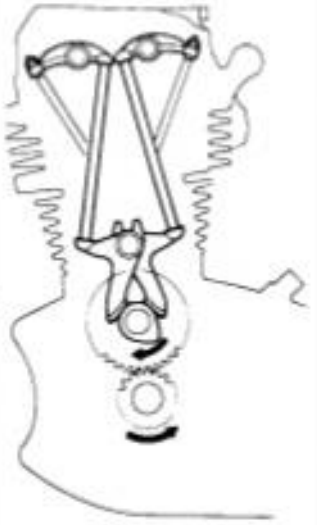
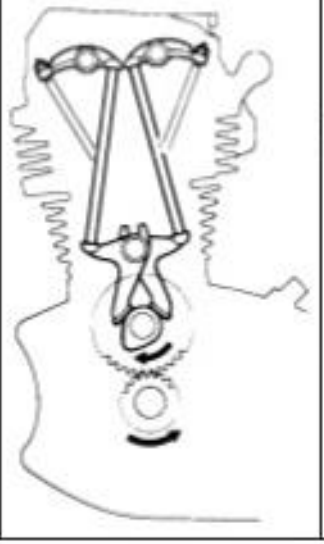
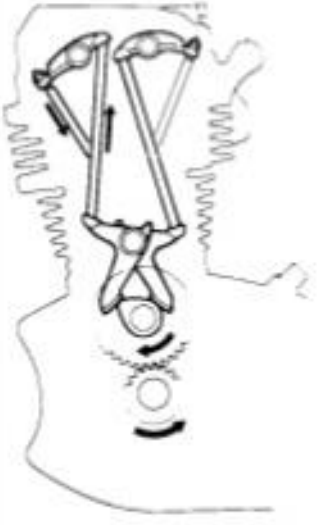
FUNCIONAMENTO DAS VÁLVULAS
Um excêntrico aciona uma haste impulsora e um balancim. Quando o tucho e a haste impulsora são levantados, o balancim atua impelindo a válvula para baixo

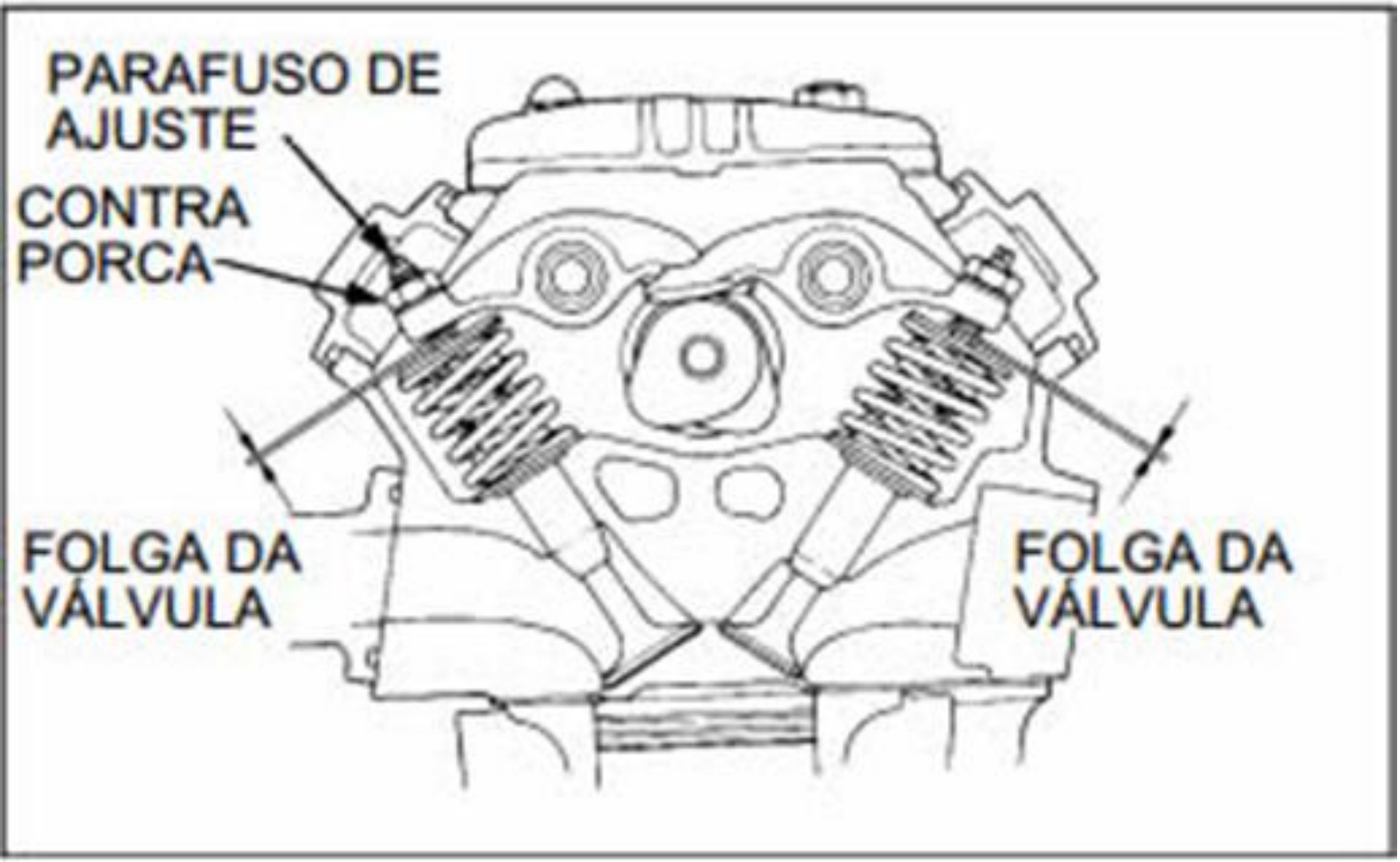
Outro tipo de balancim. Alguns motores apresentam balancins de chapa de aço estampado que atuam sobre uma rotula




A mola fecha
a válvula
Válvula
aberta
Excêntrico
levanta
o tucho
Válvula
fechada
O excêntrico
permite a
descida do
tucho

•ESQUEMA DE FUNCIONAMENTO DO SISTEMA DE ACIONAMENTO DAS VÁLVULAS

	ADMISSÃO	COMPRESSÃO	EXPANSÃO	ESCAPE
VÁLVULAS E PISTÃO				
CG 125				


PARAFUSO DE AJUSTE
CONTRA PORCA
FOLGA DA VÁLVULA
FOLGA DA VÁLVULA

Seguidor de face plana

Seguidor com rolete

Seguidor oscilante de face plana

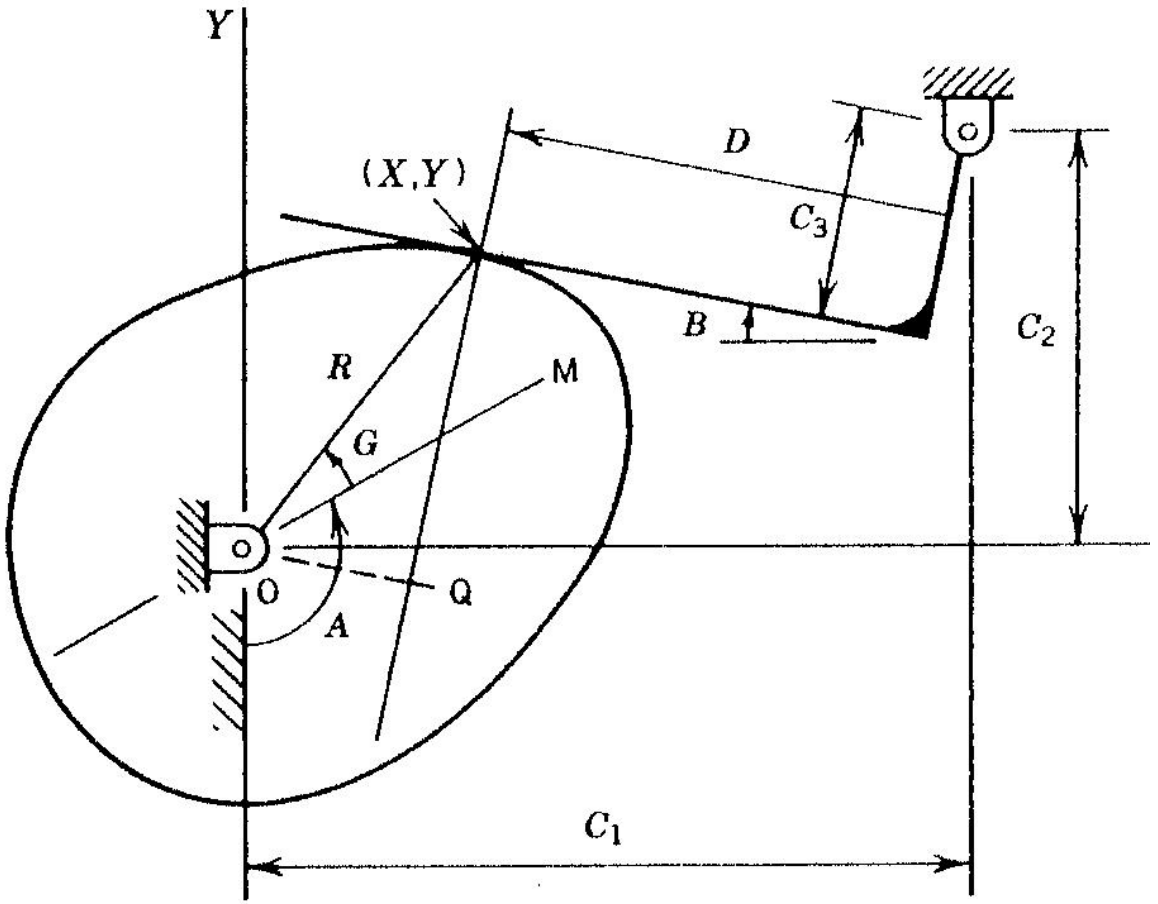


FIGURE 4.16 Cam With Pivoted, Flat-faced Follower

Seguidor oscilante de face plana

B(A) – ângulo do seguidor

A – ângulo de posição da came

$$B(A) = B_0 + f(A)$$

(R,G) – coordenadas polares do ponto de contato da came co o seguidor

D – distância do ponto de contato sobre a face do seguidor

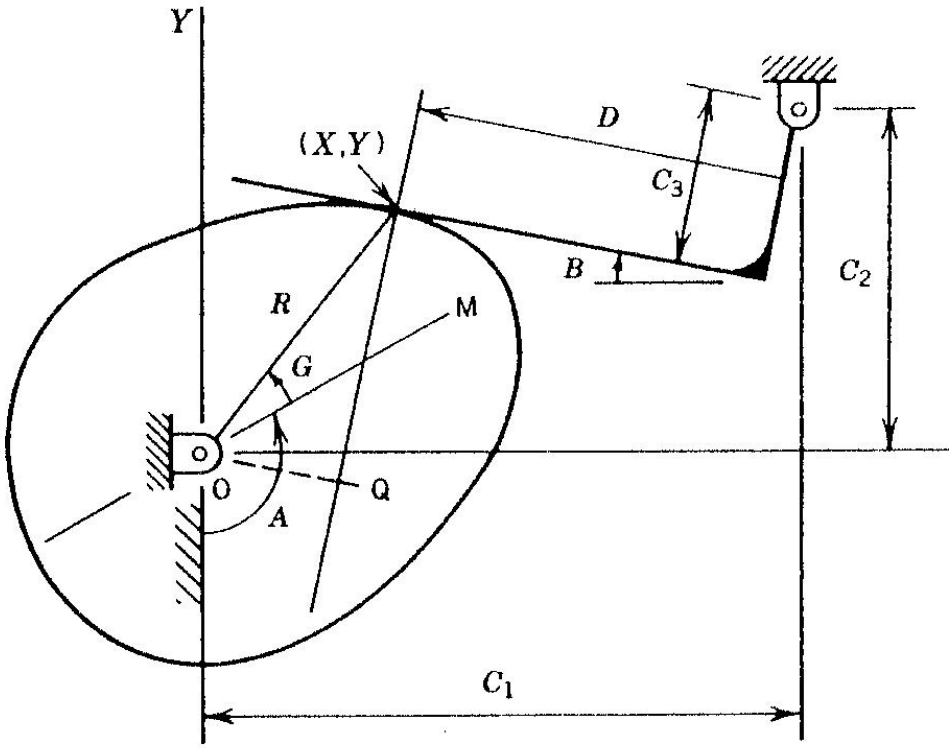


FIGURE 4.16 Cam With Pivoted, Flat-faced Follower

Seguidor oscilante de face plana

Condição de contato permanente

$$\left.\begin{aligned} V_f &= \dot{B}.D \\ V_c &= \dot{A}.\overline{OQ} \end{aligned}\right\} \Rightarrow \frac{\overline{OQ}}{D} = \frac{\dot{B}}{\dot{A}} = \frac{dB}{dA} = B'(A) = f'(A) \Rightarrow \overline{OQ} = D.f'(A)$$

$$\overline{OQ} + D + C_2.\sin(B) = C_1.\cos(B)$$

$$D = \frac{C_1.\cos(B) - C_2.\sin(B)}{1 + f'(A)}$$

Auxilia no cálculo do comprimento da face do seguidor

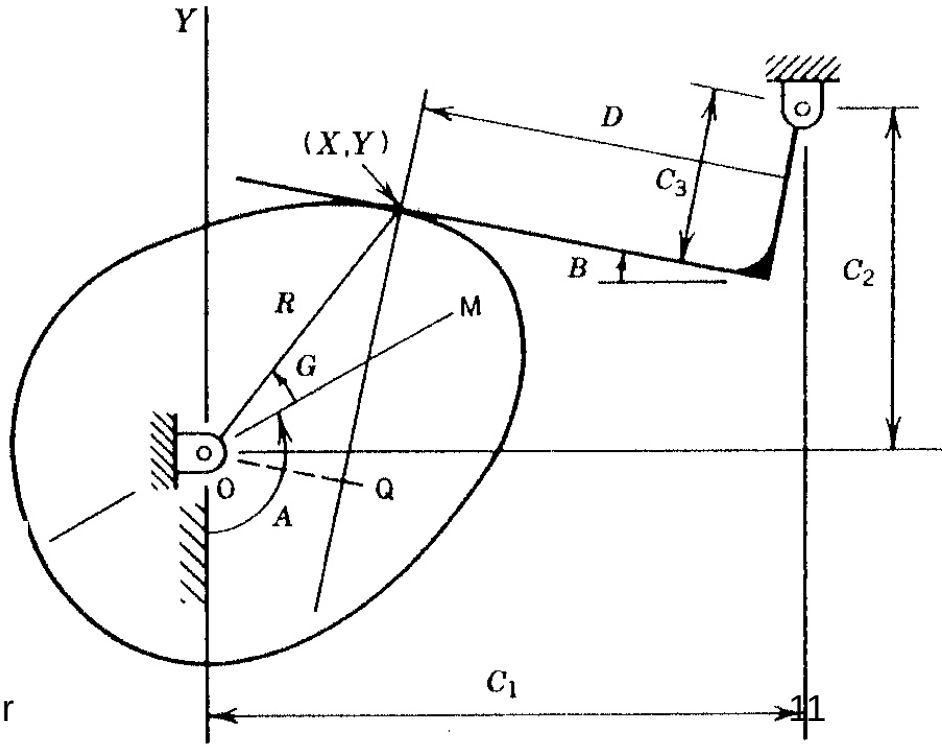


FIGURE 4.16 Cam With Pivoted, Flat-faced Follower

Seguidor oscilante de face plana

Perfil da came

$$X = C_1 - C_3.\sin(B) - D.\cos(B)$$

$$Y = C_2 - C_3.\cos(B) + D.\sin(B)$$

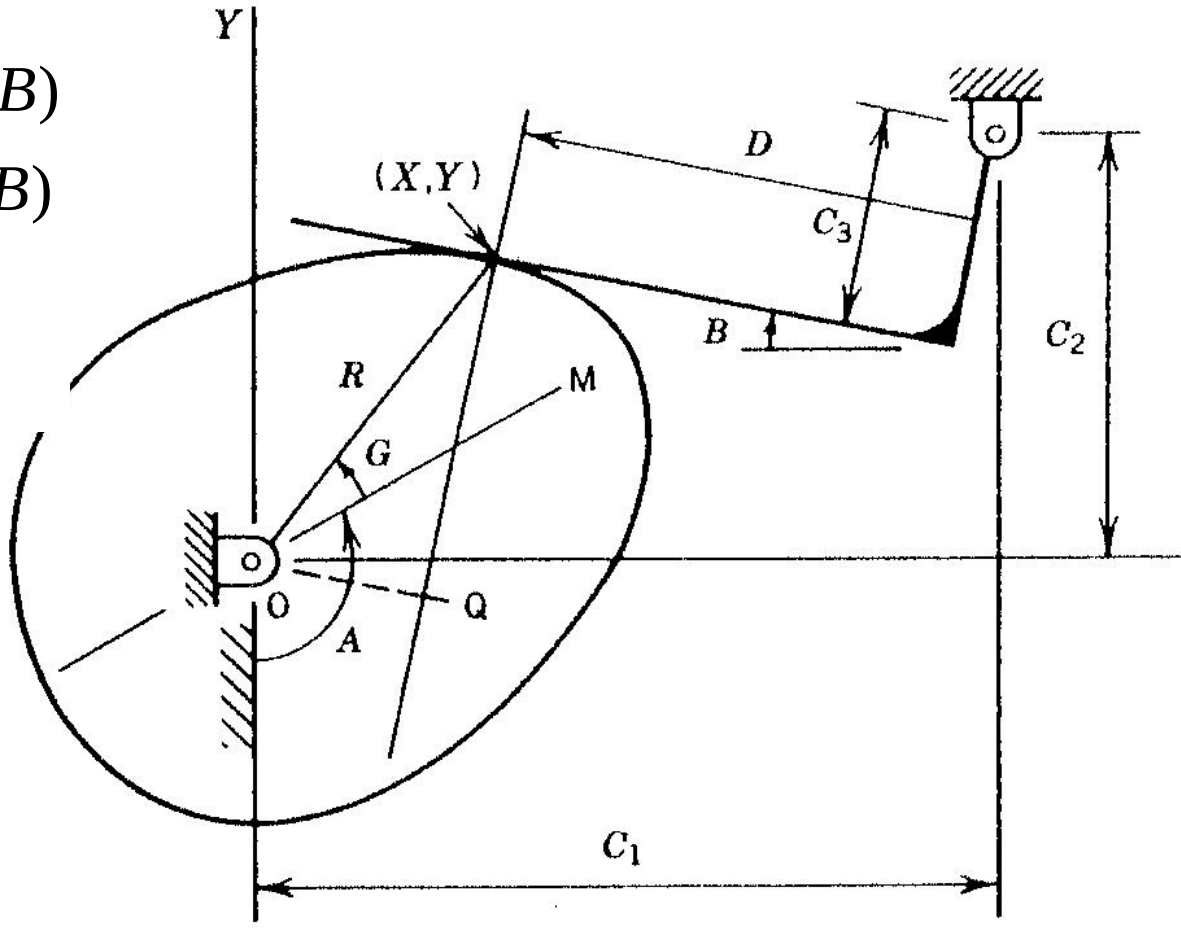
$$A + G - \frac{\pi}{2} = \arctan_2\left(\frac{Y}{X}\right)$$

$$G = \frac{\pi}{2} - A + \arctan_2\left(\frac{Y}{X}\right)$$

$$R = \sqrt{X^2 + Y^2}$$

Coordenadas do perfil

A função $\arctan_2$ está de volta!



Cam With Pivoted, Flat-faced Follower

Seguidor oscilante de face plana

Perfil da came

$$X = C_1 - C_3.\sin(B) - D.\cos(B)$$

$$Y = C_2 - C_3.\cos(B) + D.\sin(B)$$

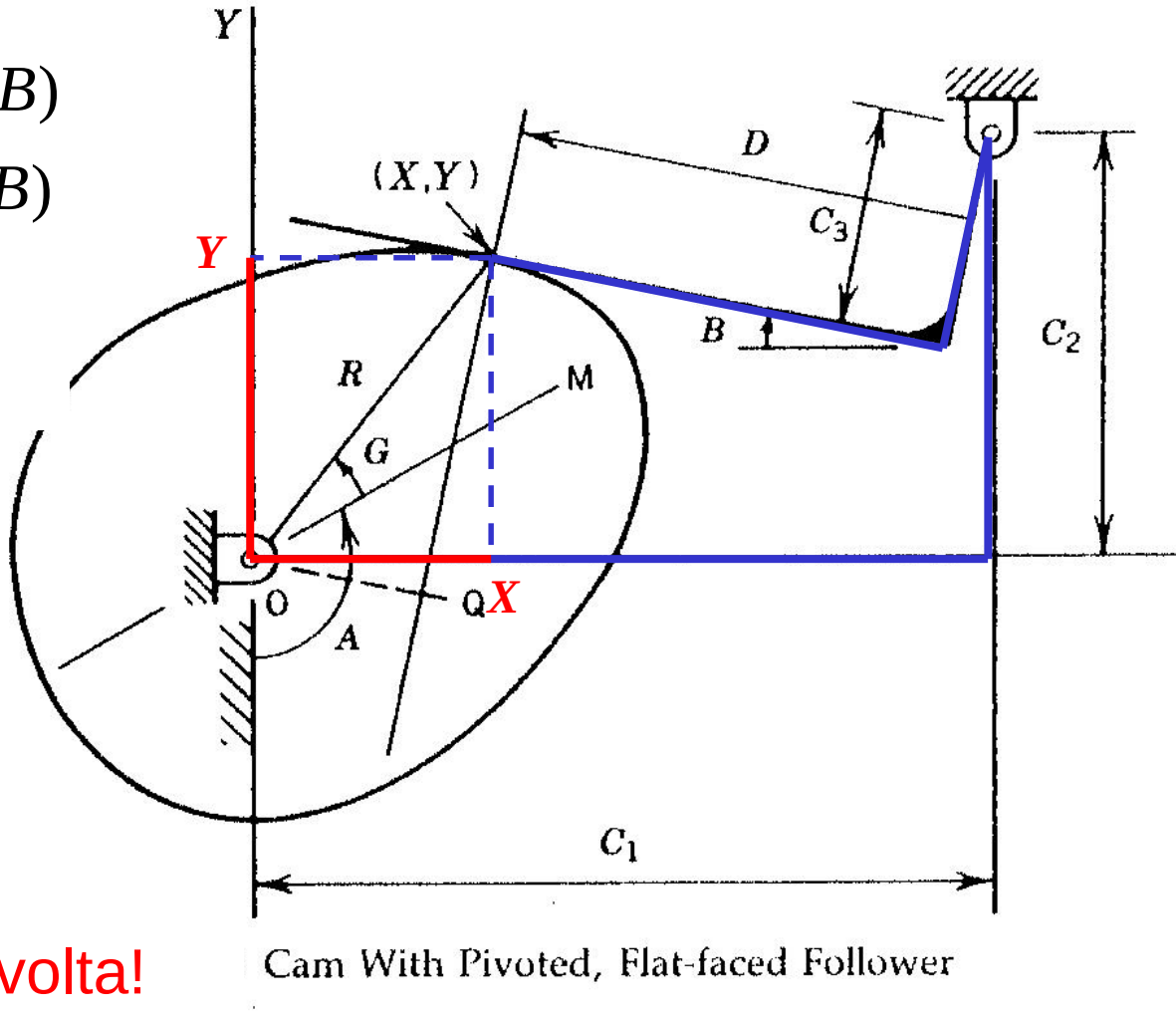
$$A + G - \frac{\pi}{2} = \arctan_2\left(\frac{Y}{X}\right)$$

$$G = \frac{\pi}{2} - A + \arctan_2\left(\frac{Y}{X}\right)$$

$$R = \sqrt{X^2 + Y^2}$$

Coordenadas do perfil

A função $\arctan_2$ está de volta!



Cam With Pivoted, Flat-faced Follower

Seguidor oscilante de face plana

Tensões de contato

$$\sigma_0 = \sqrt{\frac{F.E_1.E_2}{\pi.t.P.(E_1 + E_2)}}$$

P – raio de curvatura no ponto de contato

E_1, E_2 – módulos de elasticidade (came e seguidor)

t – espessura

F – força de contato

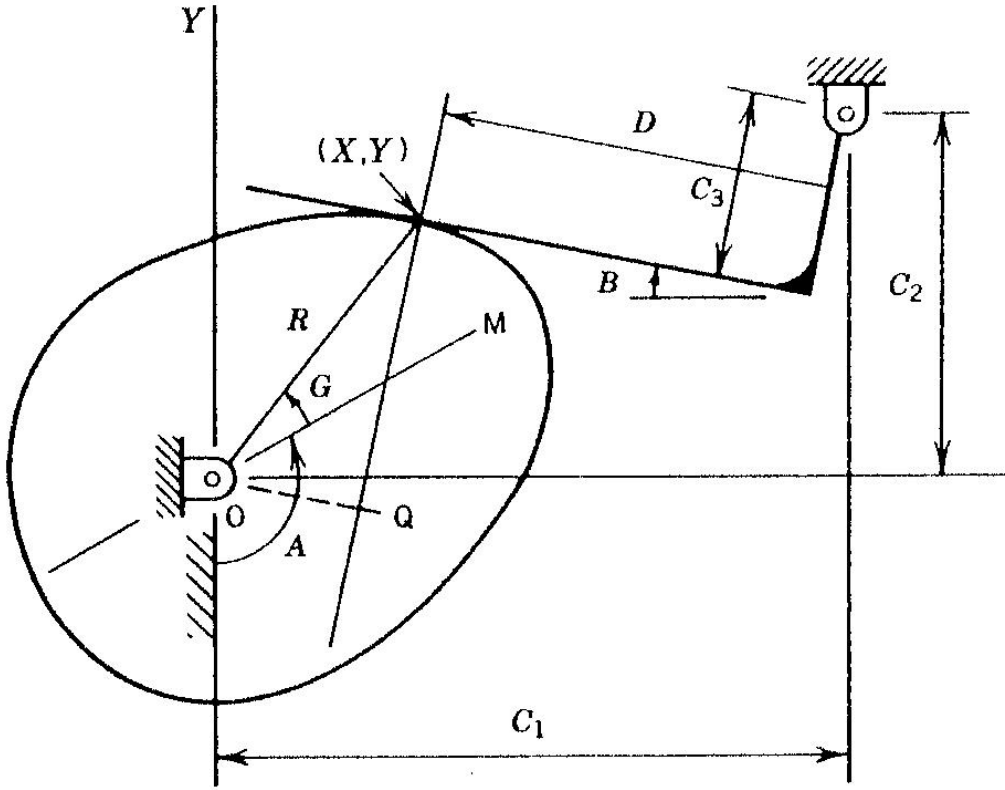


FIGURE 4.16 Cam With Pivoted, Flat-faced Follower

Seguidor oscilante de face plana

Raio de curvatura

$$R_c.\sin(C)+P.\sin(B)+D.\cos(B)+C_3.\sin(B)-C_1=0$$

$$-R_c.\cos(C)+P.\cos(B)-D.\sin(B)+C_3.\cos(B)-C_2=0$$

$$P=\frac{(1+2.f')(C_1.\sin(B)+C_2.\cos(B))+f''.D}{(1+f')^2}-C_3$$

Raio de curvatura

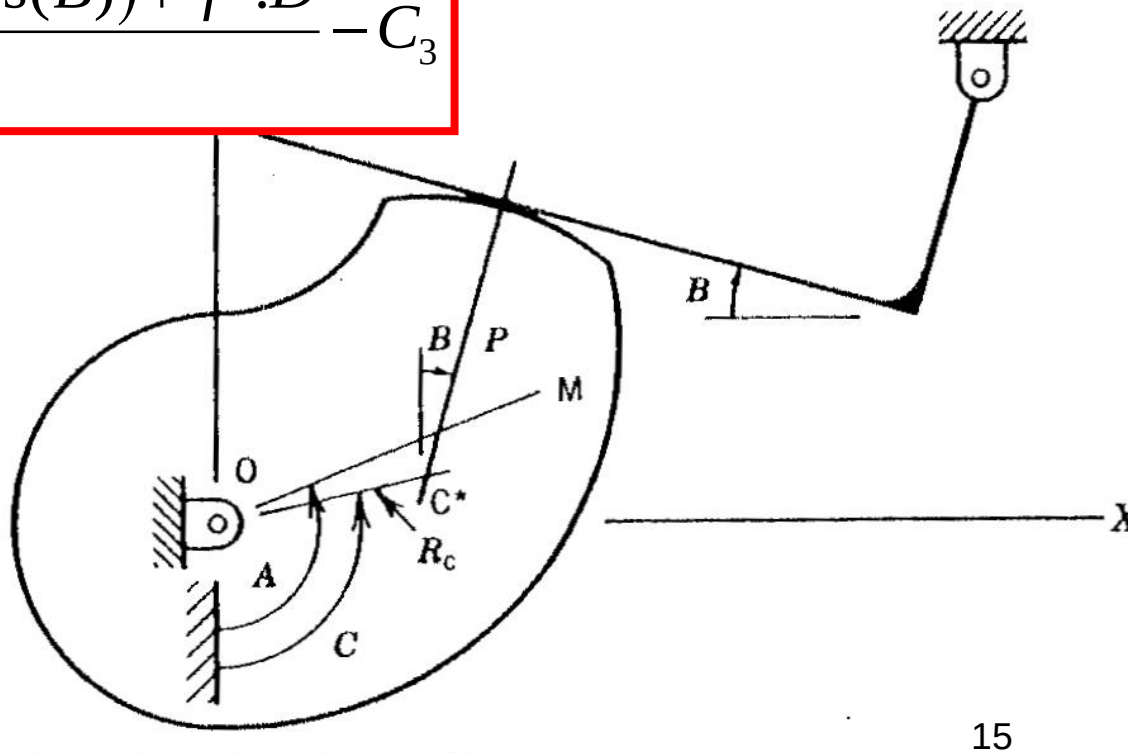


FIGURE 4.17 Radius of Curvature Determination

Seguidor oscilante com rolete

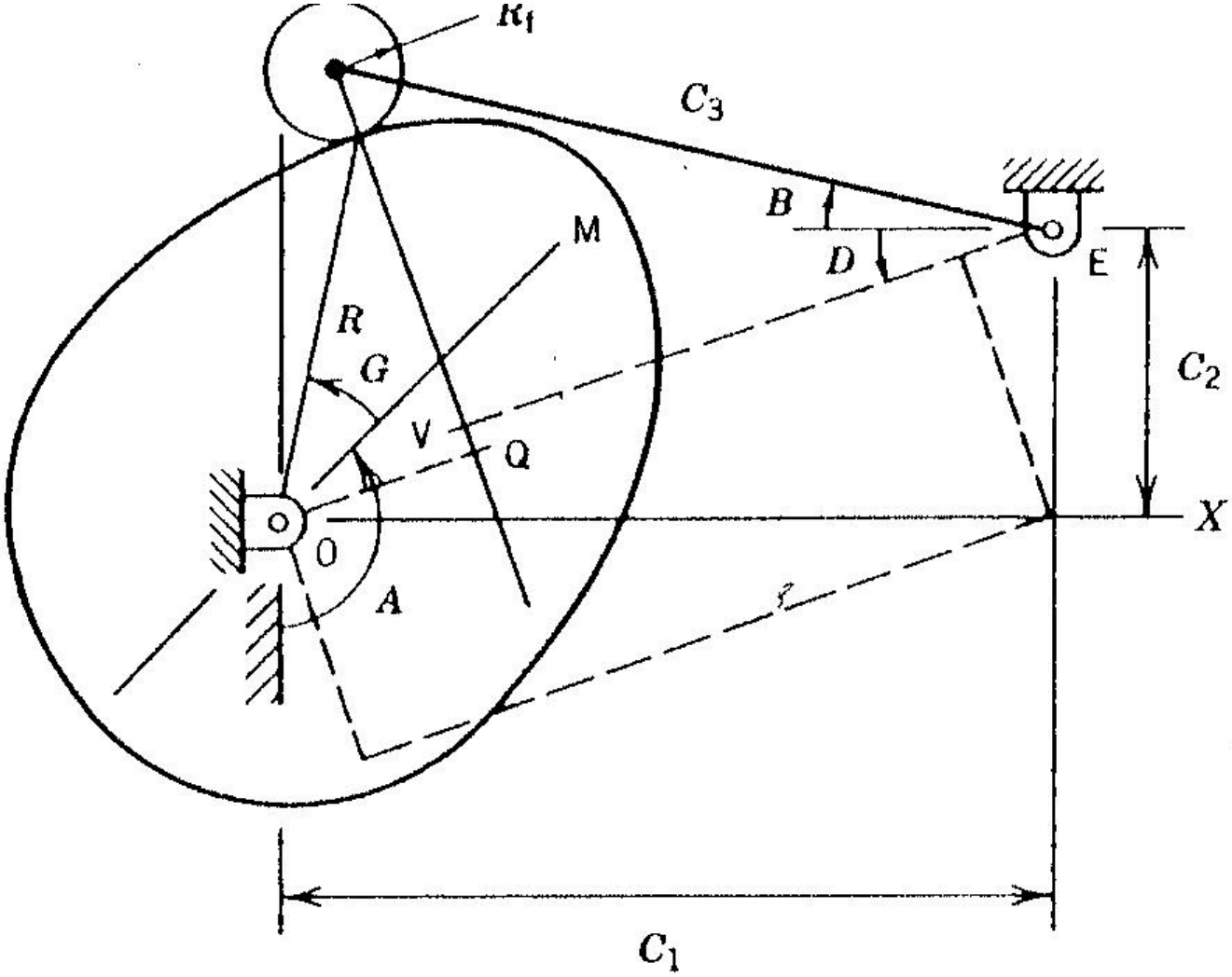


FIGURE 4.18 Cam With Pivoted Roller Follower

Seguidor oscilante com rolete

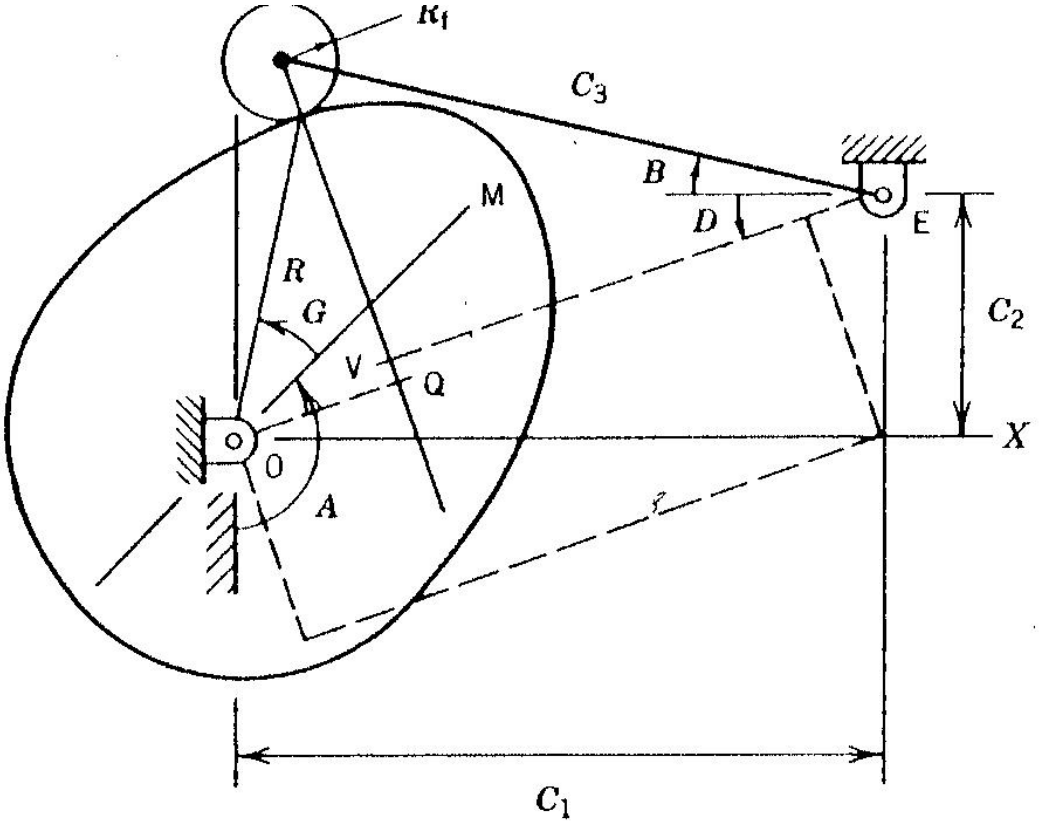


FIGURE 4.18 Cam With Pivoted Roller Follower

Ângulo do seguidor

$$B(A) = B_0 + f(A)$$

B(A) – ângulo do seguidor

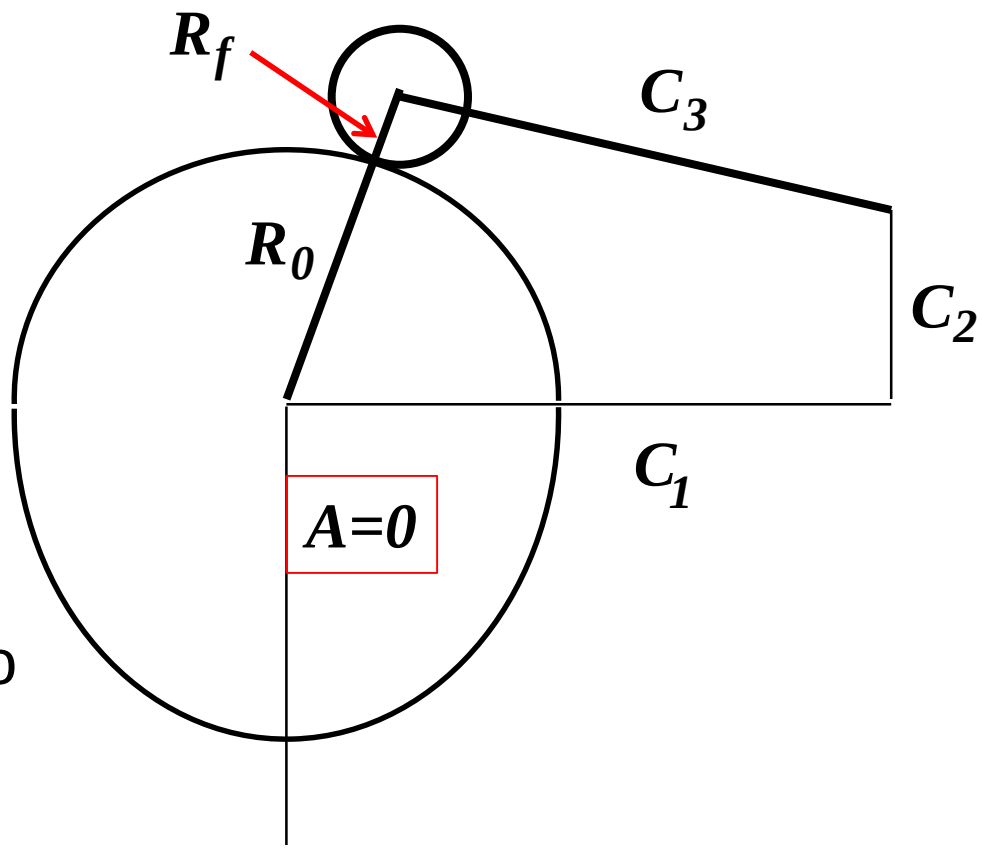
A – ângulo de posição da came

B_0 – ângulo do seguidor para A=0

Seguidor oscilante com rolete

Ângulo do seguidor

$$B(A) = B_0 + f(A)$$



O valor de B_0 pode ser obtido numericamente através da expressão:

$$\left(R_0 + R_f\right)^2 = \left(C_1 - C_3.\cos(B_0)\right)^2 + \left(C_2 + C_3.\sin(B_0)\right)^2$$

Seguidor oscilante com rolete

Condição de contato permanente: orientação da linha de contato

$$\left.\begin{aligned} V_c &= \dot{A}.\overline{OQ} \\ V_f &= \dot{B}.\overline{VE} \end{aligned}\right\} \Rightarrow \dot{A}.\overline{OQ} = \dot{B}.\overline{VE}$$

$$\overline{OQ} = \frac{\dot{B}}{\dot{A}}.\overline{VE}$$

$$\overline{OQ} = \frac{dB}{dA}.\overline{VE}$$

$$\boxed{\overline{OQ} = f'.\overline{VE}}$$

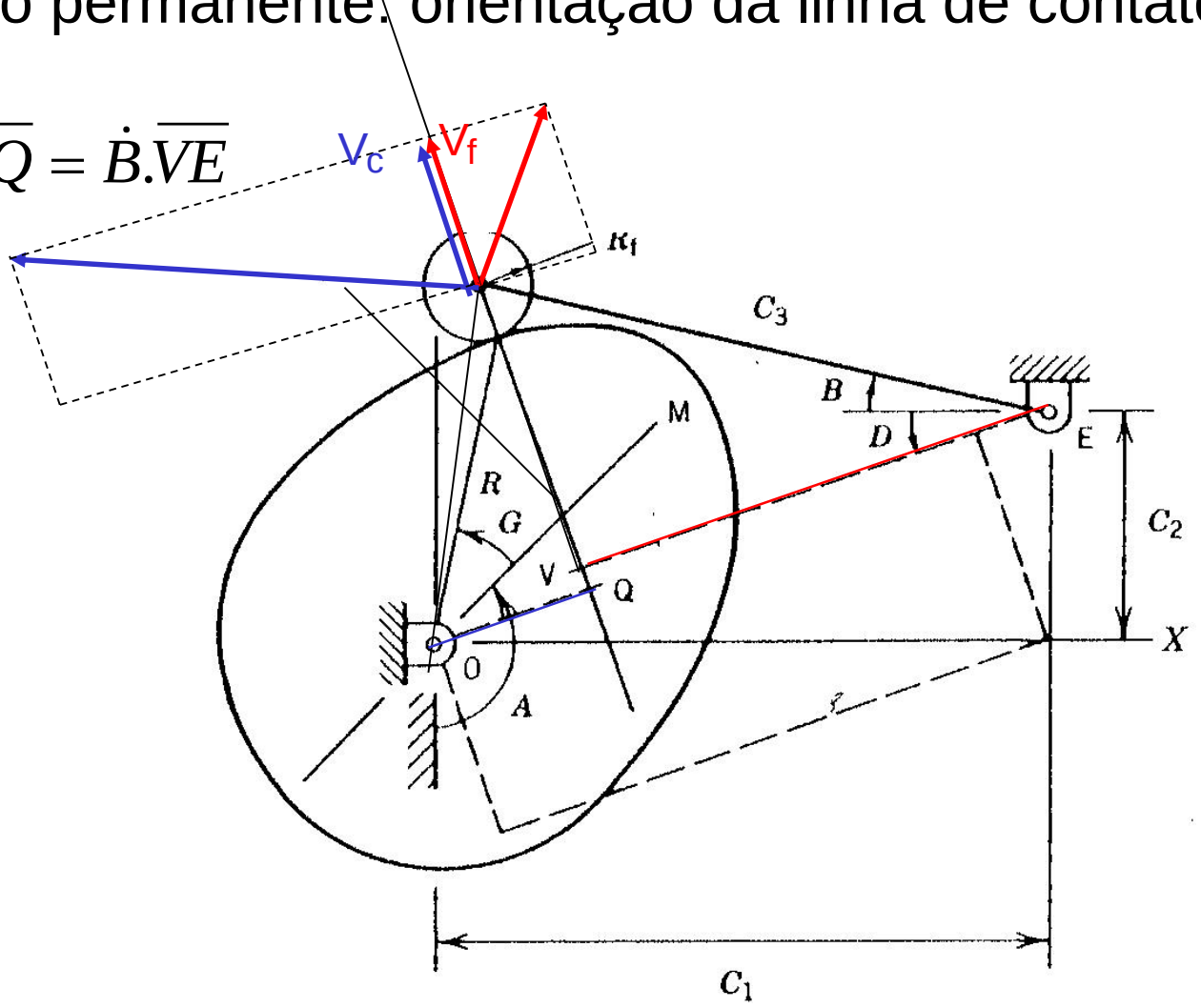


FIGURE 4.18 Cam With Pivoted Roller Follower

Seguidor oscilante com rolete

Condição de contato permanente: orientação da linha de contato

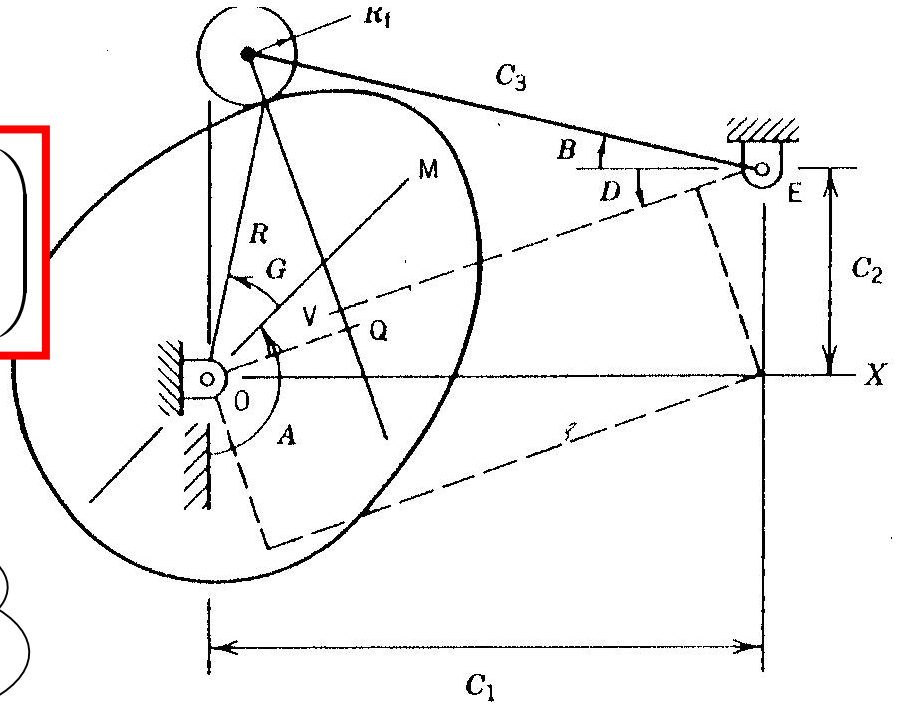
$$\overline{OQ} = f'.\overline{VE}$$

$$\overline{VE} = C_3.\cos(B+D) = C_3.\left(\cos(B).\cos(D) - \sin(B).\sin(D)\right)$$

$$\overline{OQ} + \overline{VE} = C_1.\cos(D) + C_2.\sin(D)$$

$$D = \arctan\left(\frac{C_3.(1+f').\cos(B) - C_1}{C_3.(1+f').\sin(B) + C_2}\right)$$

orientação da linha de contato



Cuidado para não confundir com a distância D do ponto de contato do seguidor de face plana!

FIGURE 4.18 Cam With Pivoted Roller Follower

Seguidor oscilante com rolete

Coordenadas do perfil da came (ponto de contato)

$$X = C_1 - C_3.\cos(B) + R_f.\sin(D)$$

$$Y = C_2 + C_3.\sin(B) - R_f.\cos(D)$$

$$A + G - \frac{\pi}{2} = \arctan_2\left(\frac{Y}{X}\right)$$

$$G = \frac{\pi}{2} - A + \arctan_2\left(\frac{Y}{X}\right)$$

$$R = \sqrt{X^2 + Y^2}$$

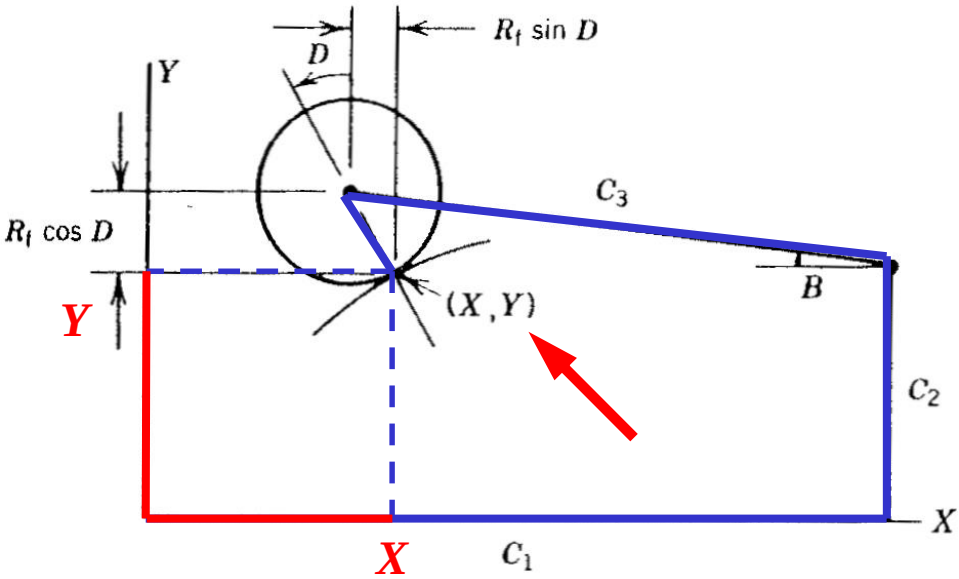


FIGURE 4.19 Cam Profile Determination

Coordenadas do perfil

A função $\arctan_2$ está de volta!

Seguidor oscilante com rolete

Tensão de contato

$$\sigma_0 = \sqrt{\frac{F.E_1.E_2.\left(P + R_f\right)}{\pi.t.P.R_f.\left(E_1 + E_2\right)}}$$

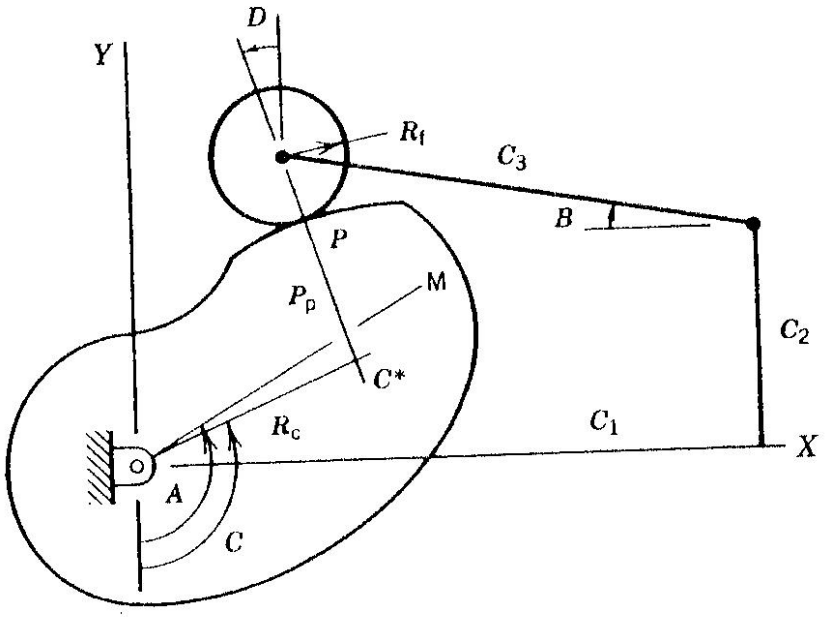


FIGURE 4.20 Radius of Curvature Determination

F – força de contato

E_1, E_2 – módulos de elasticidade (came e seguidor)

P – raio de curvatura no ponto de contato

R_f – raio do rolete

t – espessura

Seguidor oscilante com rolete

Raio de curvatura no ponto de contato

$$R_c.\sin(C) - P_p.\sin(D) + C_3.\cos(B) - C_1 = 0$$

$$-R_c.\cos(C) + P_p.\cos(D) - C_3.\sin(B) - C_2 = 0$$

(ver desenvolvimento no livro)

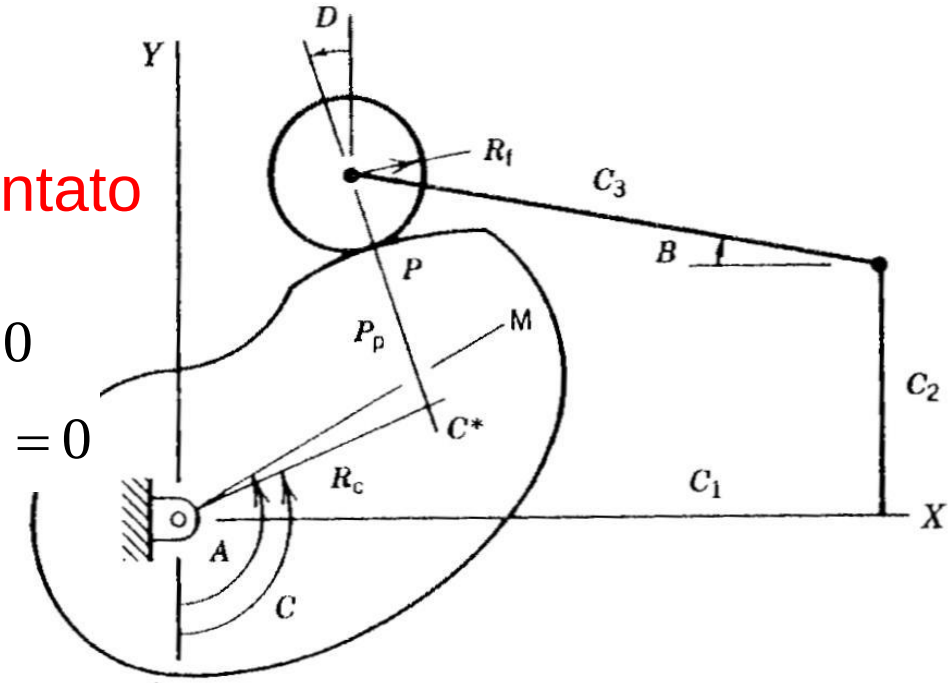


FIGURE 4.20 Radius of Curvature Determination

$$D' = \frac{C_3.f''.\left(C_2.\cos(B) + C_1.\sin(B)\right) - C_3^2.\left(1+f'\right)^2 + C_3.f'.\left(1+f'\right)\left(C_1.\cos(B) - C_2.\sin(B)\right)}{C_1^2 + C_2^2 + C_3^2.\left(1+f'\right)^2 + 2.C_3.\left(1+f'\right)\left(C_2.\sin(B) - C_1.\cos(B)\right)}$$

$$P = \frac{C_2 + C_3.\left(1+f'\right).\sin(B)}{\left(1-D'\right).\cos(D)} - R_f$$

Exercícios recomendados

Exercício 4.12

Exercício 4.19

4.12 For a particular cam with a pivoted, flat-faced follower, the follower rotational displacement is given by

$$f(A) = 0.08\,[1 - \cos(2A/1.65)] \qquad 0 \leq A < 1.65\pi$$

$$= 0.0 \qquad 1.65\pi \leq A < 2\pi$$

The dimensional parameters are $C_1 = 9.77$ in., $C_2 = 1.33$ in., and $C_3 = 0.93$ in. The angle B_o is zero.

a. Determine the minimum radius for the cam profile;

b. For $A = 1.23\pi$, determine the polar coordinates for the contact point on the cam profile;

c. For $A = 1.23\pi$, determine the radius of curvature for the contact point on the cam profile.

4.19 A cam with a pivoted, flat-faced follower is connected to a sliding link as shown. The angular displacement of the follower is given by

$$B(A) = B_o + f(A)$$

where $f(A)$ is the displacement function and B_o is the minimum rotation. The distance D and the angle C are known constants.

a. Obtain an expression for the velocity coefficient, $K_x = dX/dA$, in terms of B_o, C, D, f, and f';

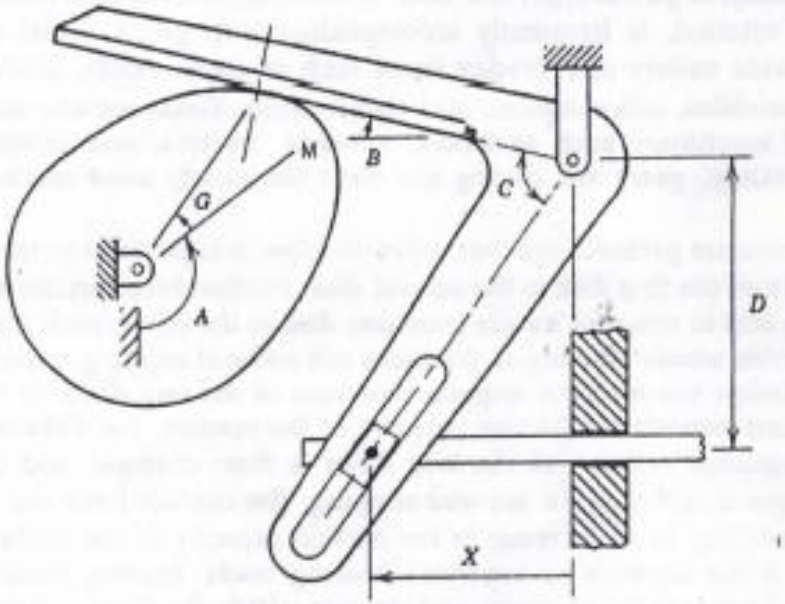
b. If the displacement function is

$$f(A) = 0.32\,[1 - \cos(2\pi A/A_1)] \qquad 0 \le A < A_1$$
$$= 0.0 \qquad A_1 \le A < 2\pi$$

where

$A_1 = 1.65\pi$ radians
$B_o = 0.21$ radians
$C = 1.02$ radians
$D = 14.5$ in.

then, evaluate K_x for $A = 1.22$ radians.



oscillante

Dicas

Web-Based Mechanism Design and Analysis

http://www.softintegration.com/chhtml/toolkit/mechanism/

APM Cam (programa para projeto de cames)

http://www.apm.ru/eng/products/apm/apmcameng

Referência

Doughty, S.. MECHANICS OF MACHINES. New York: John Wiley, 1988.

Capítulo 4